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TWO DECAYS OF STORED APPLES.

H. J. EUSTACE.

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BULLETIN No. 235.

TWO DECAYS OF STORED APPLES.

H. J. EUSTACE.

SUMMARY.

I. A rot of apples, very similar in gross characteristics to the "pink rot" caused by *Cephalothecium roseum*, is produced by a fungus of the genus *Hypochnus*.

Inoculation experiments prove the fungus to be parasitic on apple and pear. It is a wound parasite and cannot grow through sound epidermis.

Since only apples that were attacked by the scab were affected with the rot, the importance of spraying to prevent scab is again emphasized.

II. During the winter it was noticed that a peculiar core decay had developed in Baldwin apples. While the fruit appeared externally to be perfectly sound an area about the core was decayed.

The trouble could not be traced to fungi or bacteria. It did not seem to be influenced by the use or absence of fertilizers, nor to have any relation to the kind of soil, nor to imperfect ripening of the fruit. It may have been caused by overbearing, by the unusually wet season, or by the combination of these conditions.

Baldwin apples placed in cold storage (30° F.) in October were entirely free from even a trace of the decay in June.

I. ANOTHER APPLE ROT FOLLOWING SCAB.

In Bulletin No. 227 of this Station[1] is described an apple rot following scab, to which the popular name " Pink Rot " has been given. Some weeks after that Bulletin had been sent to the printers, specimens of diseased Rhode Island Greening apples were received at the Station from a cold storage fruit house in Orleans county. The decayed areas on these fruits presented the same general appearance as the spots caused by *Cephalothecium roseum*, which affected so many of the Rhode Island Greening apples during the fall of 1902. However, a microscopic examination at once showed that the fungus associated with the decayed tissue of these apples was not *C. roseum*, but an entirely different one.

On account of this similarity to the decay caused by *C. roseum* and the fact that the fungus found associated with the decay of these apples seemed to be a very unusual one as a cause of fruit decay, especially of decay of fruits in cold storage houses, it was decided to make an investigation of it.

Affected apples when first taken out of storage, had the appearance shown in Plate I, Fig. 1. The fruit was marked with brown, sunken, decayed spots of various sizes up to an inch in diameter, circular in outline except where several had coalesced. The epidermis was often ruptured. After an affected apple had been left in a moist chamber for a few days an abundance of a dirty-white, cob-web-like mold would make its appearance on each decayed spot (Plate I, Fig. 2).

Examination of the center of these decayed spots showed in each case the presence of apple scab, *Fusicladium dendriticum*, making it appear that the fungus causing the rot had gained an entrance through the rupture made by the growth of the scab. It was noticeable that the rot did not develop under the large spots that seemed to have corked over, but upon the fresh and apparently young ones that were evidently formed late in the season.

In a comparison of the " Pink Rot " of apples caused by the

[1]Eustace, H. J. A Destructive Apple Rot Following Scab. N. Y Agr. Exp. Station Bul. 227. D. 1902.

fungus, *C. roseum*, and the decay caused by this new fungus there are some differences in gross appearance by which they can be distinguished. On fruit affected with *C. roseum* there is usually a conspicious white or pinkish growth of the fungus in the center of an affected spot; whereas this new fungus does not show at all conspiciously on the surface of a decayed spot until made to do so by artificial conditions. On fruit, *C. roseum* is a very shallow growing fungus, penetrating the tissue not much more than an eighth of an inch, while this new fungus grows much deeper and in its late stage extends to the core. The tissue decayed by *C. roseum* has a very characteristic and decidely bitter taste, but the tissue decayed by this other fungus is only slightly bitter.

The scantiness of the fruiting of the fungus both on affected apples and in pure cultures was very remarkable. On one of the diseased specimens first received there were found a few spores, but for some time afterward affected apples that were put in moist chambers refused to develop any spores of the fungus. In the greater number of the cultures made, using several different media, the fungus would not fruit, though there would develop an abundance of the mycelium. But late in April, several cultures made from diseased tissue from artificially inoculated apples produced spores in abundance, and about this time affected apples that had been placed in moist chambers also fruited.

A microscopic examination will at once show that the fungus associated with this decay is entirely different from *C. roseum*. As seen under a microscope the most prominent and striking thing about the fungus is the constant presence of clamp connections at each septum of the hyphae (Plate II, Fig. 2). This character will be found very useful in identifying the fungus. As these clamp connections were known to occur chiefly on species of the Basidiomycetes—a class of fungi including the rusts, smuts, mushrooms and puff balls—to find them on a fungus causing a decay of apples was very unusual.

While we were engaged in making drawings of the fungus and attempting to classify it, specimens were shown to Mr. H. Hasselbring, who happened in the laboratory. Mr. Hasselbring expressed the opinion that it was a species of *Hypochnus*. Subse-

quent studies convinced us of the correctness of this determination, but whether the fungus is referable to any of the described species of *Hypochnus* we have been unable to decide.

There are over sixty species of *Hypochnus* described in Saccardo's *Sylloge Fungorum*, and all except three or four are recorded as saprophytes.

That a fungus belonging to a genus so generally regarded as saprophytic should be found as a parasite on fruit is remarkable. However, this was exactly the case when *C. roseum* became parasitic on apples in 1902. Previous to that time it had been regarded by mycologists as a harmless saprophyte.

The basidia of this fungus *Hypochnus* sp., are loosely aggregated, and usually bear four sterigmata. The hymenium consists of loose floccose or arachnoid hyphae. The spores are uncolored and smooth, one-celled and usually obovate. As we have found them they measure from 4 to $5\frac{1}{2}\mu$ long by $2\frac{1}{2}$ to $3\frac{1}{2}\mu$ wide, the most common size being 5 x $3\frac{1}{3}\mu$ (Plate II, Fig. 1).

The amount of damage that this fungus has done to stored apples is probably not large, but specimens of affected fruit have been received from several different localities, and it is not unlikely that it has caused some loss in many storage houses and fruit cellars in Western New York.

We have found it on but two varieties, Baldwin and Rhode Island Greening. However, inoculations proved that it would grow as readily on other varieties as upon these two.

Artificial inoculations of the fungus on apples and pears were made to prove its parasitism. In all of the inoculations the characteristic rot always developed, while check fruits kept under parallel conditions always remained sound.

Only sound, perfect specimens of fruits were used for inoculation experiments. They were immersed in a 1-1000 solution of corrosive sublimate to destroy any spores that might be present. This was washed off with distilled water and the surplus water absorbed with a piece of sterilized cotton. Two fruits of the same variety were placed in a large moist chamber that had been washed out with a 1-1000 solution of corrosive sublimate. The epidermis of each fruit was punctured with a sterilized needle and some of the fungus growing pure on bean stems, potato agar or

apple agar was placed in the puncture of one fruit, the other being reserved for the check. (Plate III.)

TABLE I.—INOCULATION ON FRUIT WITH PURE CULTURES OF *Hypochnus* SPECIES.

ON APPLES.

Date of inoculation.	Variety.	Date of examination.	Diameter of decayed spot at point of inoculation.	Condition of check.
Mar. 7...	R. I. Greening	Mar. 16....	5 MM...	Sound.
" 7...	" "	" 16....	3½ "	"
" 16...	Holland	" 23....	10 "	"
" 16...	Baldwin	" 23....	5 "	"
" 16...	Boiken	" 23....	6 "	"
" 16...	Pewaukee	" 23....	8 "	"
" 16...	R. I. Greening	" 23....	7 "	"
" 16...	Paragon	" 23....	7 "	"
" 16...	Hubbardston	" 23....	6 "	"
" 16...	Ontario	" 23....	8 "	"
" 16...	Mann	" 23....	6 "	"
" 16...	Monmouth	" 23....	5½ "	"
" 16...	Northwestern Greening	" 23....	8 "	"
" 16...	Rome Beauty	" 23....	6 "	"
" 19...	Princess Louise	" 26....	9 "	"
" 19...	Esopus Spitzenberg	" 26....	8 "	"
" 19...	Tufts	" 26....	7 "	"
" 19...	Amasia	" 26....	4½ "	"
" 19...	Starbuck	" 26....	5 "	"
" 19...	Stayman	" 26....	6 "	"
" 19...	Pumpkin Sweet	" 26....	6 "	"
" 19...	Coon Red	" 26....	5½ "	"
" 19...	Thornton	" 26....	5 "	"
" 19...	Dickinson	" 26....	5 "	"
" 20...	Nelson	" 27....	4 "	"
" 20...	Jones Seedling	" 27....	5 "	"
" 20...	Ben Davis	" 27....	5 "	"
" 20...	Greenville	" 27....	6 "	"
" 20...	Ontario	" 27....	5 "	"
" 20...	Moyer Prize	" 27....	5 "	"
" 20...	Moore Sweet	" 27....	9 "	"
" 20...	Golden Medal	" 27....	9 "	"
" 20...	Hargrave	" 27....	4 "	"
" 20...	Jacob	" 27....	9 "	"
" 20...	Ewalt	" 27....	6 "	"

ON PEARS.

April 6...	Bordeaux	April 14...	5MM.	Sound.
" 6...	Pound	" 14...	6 "	"
" 6...	P. Barry	" 14 ..	7 "	"
" 6...	Garber	" 14...	4½ "	"
" 6...	Josepheus de Malines	" 14...	8 "	"

As has been stated the rot always appeared to start in an apple through a rupture in the epidermis caused by scab. It was desirable to know if the fungus could penetrate the unbroken epidermis and cause the rot. To determine this, artificial inoculations were made with the same care and under the same sterile conditions as previously described. Two apples of the same variety were placed in a moist chamber; a bit of the fungus from a pure culture was placed upon one without puncturing or injuring the epidermis in any way. The other fruit was inoculated by puncture as previously described. The rot did not develop in any of the fruits inoculated on unbroken epidermis, though a large surface growth of the fungus appeared, but on all the fruits inoculated through a puncture the rot was produced.

TABLE II.—INOCULATIONS MADE ON SOUND EPIDERMIS AND THROUGH A PUNCTURE.

Date of inoculation.	Variety.	Epidermis.	Date of examination.	Condition.
Mar. 24.	Princess Louise	Sound	Mar. 31.	Fruit sound.
" " .	" "	Punctured.	" " .	Decayed spot, 8mm. in diameter.
" " .	Ben Davis	Sound	" " .	Fruit sound.
" " .	" "	Punctured.	" " .	Decayed spot, 5½mm. in diameter.
" " .	Titus Pippin...	Sound	" " .	Fruit sound.
" " .	" " ...	Punctured	" " .	Decayed spot, 6mm. in diameter.
" " .	Shannon	Sound	" " .	Fruit sound.
" " .	"	Punctured.	" " .	Decayed spot, 5mm. in diameter.
" " .	Baldwin.....	Sound	" " .	Fruit sound.
" " .	"	Punctured.	" " .	Decayed spot, 5mm. in diameter.
" " .	Mann	Sound	" " .	Fruit sound.
" " .	"	Punctured.	" " .	Decayed spot, 7mm. in diameter.
" " .	Stayman	Sound	" " .	Fruit sound.
" " .	"	Punctured.	" " .	Decayed spot, 6mm. in diameter.
" " .	R. I. Greening.	Sound	" " .	Fruit sound.
" " .	" " .	Punctured.	" " .	Decayed spot, 6½mm. in diameter.

The results prove that the fungus is a wound parasite, as the mycelium is entirely unable to penetrate the unbroken epidermis and produce the rot.

That the rot produced by the artificial inoculations was caused by the fungus with which they were made, *Hypochnus* sp., was definitely determined by a microscopic examination, or by making cultures from some of the affected tissue removed under sterile conditions. In most of the examinations both methods were used. In all but two or three cultures the fungus grew absolutely pure.

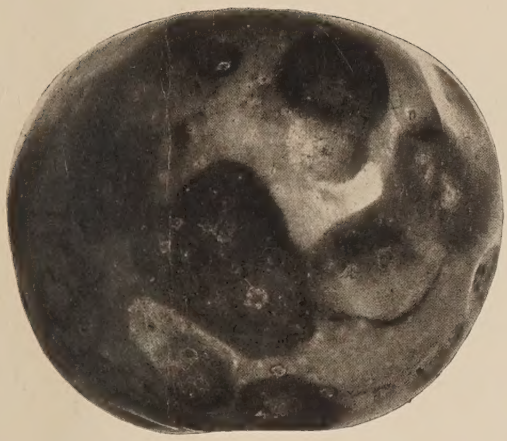
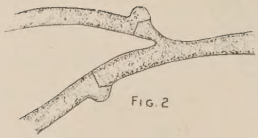
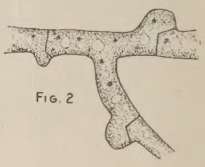


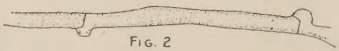
FIG. 1

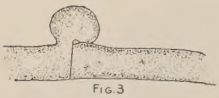
FIG. 2

PLATE I.—GREENING APPLES AFFECTED WITH *Hypochnus* ROT: FIG. 1, APPEARANCE WHEN REMOVED FROM STORAGE; FIG. 2, DEVELOPMENT OF FUNGUS AFTER THE FRUIT HAS BEEN IN A MOIST CHAMBER A FEW DAYS.









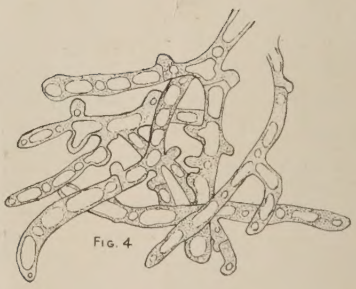


Plate II.—The Fungus, *Hypochnus* Species:
Fig. 1, Spores x 725; Fig. 2, Hyphae x 725; Fig. 3, A Clamp Connection, Much Enlarged; Fig. 4, A Portion of the Hymenium x 725.

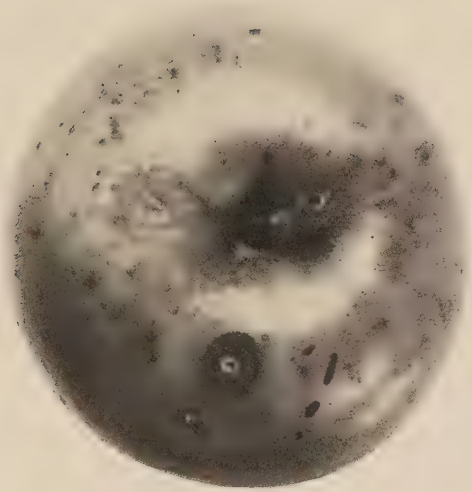


FIG. 1

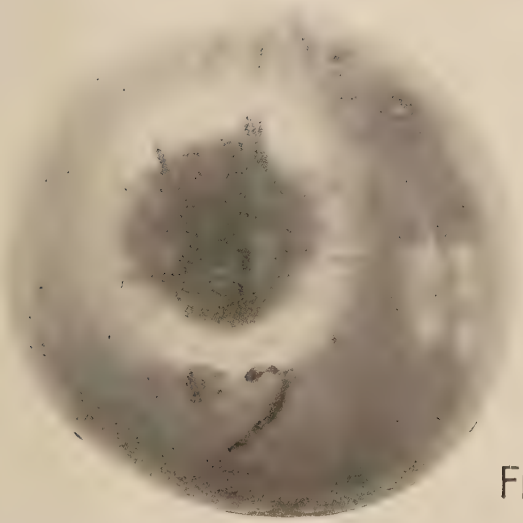


FIG. 2

PLATE III.—ARTIFICIAL INOCULATIONS ON NORTHWESTERN GREENING APPLES:

FIG. 1, TEN DAYS AFTER INOCULATION WITH PURE CULTURE OF *Hypochnus* SPECIES; FIG. 2, CHECK—PUNCTURE TO RIGHT OF "2." NATURAL SIZE.

PLATE IV.—BALDWIN APPLE AFFECTED WITH THE CORE DECAY.

The fact that only apples affected with scab were attacked by this fungus, as was the case with "Pink Rot," emphasizes more emphatically than ever the great importance of protecting the apple crop from scab by thorough and persistent spraying with bordeaux mixture.

The finding of decayed fruit in several cold storage houses indicates that the low temperature cannot be relied upon to hold the trouble entirely in check, though it is probable that it does retard its development to some degree.

II. A CORE DECAY OF BALDWIN APPLES.

During the past winter our attention was called to a very peculiar decay of Baldwin apples. Outwardly the fruit would appear to be perfectly sound, but upon being cut a part of the tissue surrounding the core was found to be decayed. (Plate IV.)

The decayed tissue, which was brown, dry-rotten and tasteless, was entirely surrounded by sound, healthy tissue of normal quality. This indicated that the trouble was not of fungous origin. However, to determine this point definitely, sections of affected tissue were examined microscopically for fungus hyphae and bacteria, but none could be found. Petri dishes containing neutral potato agar were inoculated at several different points with small pieces of the diseased tissue removed under sterile conditions. No growth appeared at any of the points of inoculation, and it was very evident that the trouble was not caused by fungi or bacteria.

Sections of affected tissue were tested with a solution of iodine for starch, but none was found, indicating that the tissue had ripened properly and the decay had developed subsequently.

The trouble was first discovered in apples that were undersized and poorly colored, and affected specimens were usually poor in flavor. A little later first class fruit was examined and found to be affected.

An effort was made to determine if there was any correlation of the size, color or flavor of the fruit with the core decay. Quantities of apples of different sizes and degrees of coloring were examined, but in all cases the decay was found. There was no difference in the size of the decayed area whether the

fruit was large and highly colored, or small and poorly colored, or the quality good or bad

In a large fruit there was as often a small affected area as a large one, and in apples below the average size there was no constancy of the size of the affected area. But in no case did the decay ever extend outside the core line.

The conditions of ordinary storage under which the apples were kept seemed to have no relation to the decay nor to influence it. Fruit from dry and well ventilated houses was as badly affected as that from damp and poorly ventilated cellars. But fruit kept in cold storage houses was found to be entirely free from the trouble.

In the Station orchard there are certain Baldwin apple trees that have been fertilized with phosphoric acid for the two seasons of 1901 and 1902, and trees in the adjoining row that have not been fertilized with anything during the same period. A comparison of the fruit from these trees gave a good opportunity to determine if the fertilizer had any influence on the trouble. Quantities of apples from the trees that each year had been fertilized with 8 lbs. 7 ounces of South Carolina rock per tree were examined and in practically every case found to have the decay. To compare with these quantities of apples from the trees that had not been given any fertilizer were examined and the decay found in every case. Apples from other trees in the same orchard that had been fertilized with 9 lbs. of South Carolina rock to each tree for several years were examined and the decay found in practically every case.

All of these apples were harvested and put in the Station storage house on the same day, and were under parallel conditions at all times.

The constant presence of the decay in all of these apples indicates that the use of phosphoric acid as a fertilizer had no influence one way or the other upon the trouble.

It was stated by experienced apple dealers that the trouble was confined to fruit grown upon sandy soil, but we have found it as marked in apples grown on a stiff heavy clay as in those grown in a loose, light, sandy soil.

It has also been suggested that the decay is a result of improper ripening as is the case when a tree overbears. But as the trouble

was found to occur in large, highly colored and fully ripe apples with the same constancy as in small and poorly colored ones there seems to be no reason for believing the trouble due to this cause. Overbearing, however, may have some connection with, or be responsible for it. The crop of Baldwin apples in 1902 was excessively large and many trees overbore and this, possibly, is an explanation of the trouble. Then too the season of 1902 was an unusually wet one, and it may be that the excessive moisture, in addition to the overbearing, was responsible for the decay.

The fact that there is no record of a previous trouble of this kind with Baldwin apples tends to strengthen the theory that it was due to the peculiar season. But why it should be so constant in Baldwin apples and absent in the other prominent varieties is not understood.

The fruit spot of the Baldwin apple[2] is well known and in some seasons a serious trouble. Like this core decay the cause is not known, but it has been definitely determined that it is not fungi or bacteria. During the season of 1902 there was none of it in western New York, which seems to indicate that the conditions, whatever they may be, that favor its development are not the same that favor the development of the core decay.

Why this decay should be so constant in Baldwin apples and absent in the other prominent varieties we are unable to say. It was not, however, confined entirely to Baldwin apples. One hundred and twenty-two different varieties of apples, stored under the same conditions in the Station storage house were examined and specimens of Cox Pomona, Jacob, Jones Seedling, Northwest Greening, Esopus Spitzenberg, Wolf River and Peck Pleasant were found that showed the decay in varying degrees.

While the trouble appears to be one peculiar to the season, it is very clear that the conditions of storage exerted a pronounced influence on checking the decay. On April 11 and again on June 4—within a week of the end of the apple season—quantities of Baldwin apples of different grades that had been in cold storage (30 and 32° F.) since October were examined and not a single affected specimen found, while apples of the same variety under various conditions of ordinary storage invariably showed marked cases of the trouble.

[2] For a description of this trouble see Bulletin No. 164, p. 215, of this Station.